Midterm Exam

Level: 1st Year
Material: Algorithms and Static Data Structures

Date: 24/11/2025
Duration: 1h30

1. Write a function **naturalLogarithm(x: real; n: integer): real** that calculates the approximation of $ln(x)$.
   - Use only one loop for developing this function.
2. Write the main algorithm **CalculateNaturalLogarithm**.

Hints:

- Use the **Function powerXY(x, y: integer): integer** that calculates x to the power of y (x^y).
- Use the **Function abs(x: real): real** that returns the absolute value of x ($|x|$).

Exercise 3: Longest Collatz sequence under n (07 points)

The Collatz sequence for a positive integer number n ($1 \leq n \leq 1{,}000{,}000$) is given as follows:

- If n is even, the next number is $\frac{n}{2}$.
- If n is odd, the next number is $3 * n + 1$.
- Repeat until reaching 1.

Given a positive integer number n, find the number under n producing the longest sequence, and its length.

Example:

Number	Output	Length	Sequence
10	9	20	9 → 28 → 14 → 7 → 22 → 11 → 34 → 17 → 52 → 26 → 13 → 40 → 20 → 10 → 5 → 16 → 8 → 4 → 2

1. Write a **Procedure longestSequence(n: integer; VAR bestNumber, bestLength: integer)** that returns the longest sequence.
2. Write the main algorithm **CollatzSequence**.

Hints:

- Develop the **Function lengthCollatz(n: integer): integer** that returns the length of a sequence given an integer number n.

Good Luck

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Exercise 1: Palindrome (07 points)

Consider a positive integer number n that has an even number of digits, and assume that n can be transformed into a palindrome, where each pair of identical digits is placed on opposite sides (one on the left side and the other on the right side).

1. Write a function **transfromPalindrome(n: integer): integer** that takes n as input and returns $npal$, which is the palindrome obtained from transforming n.

Example:

Number (n)	Palindrome (npal)
1212	2112
123123	123321
522522	225522

The standard deviation-like value is defined as the sum of the absolute differences (ad) between the corresponding digits of two numbers at the same positions.

2. Write a function **standardDeviation(n, npal: integer): integer** that calculates the standard deviation-like value (sd) between the original integer number n and its palindrome $npal$.

Example:

Number (n)	Palindrome (npal)	Absolute difference (ad)	Standard deviation (sd)
1212	2112	1100	2
123123	123321	000202	4
522522	225522	303000	6

3. Write the main algorithm **PalindromeStandardDeviation**.

Hints:

- Develop the **Function countDigits(n: integer): integer** that counts the number of digits of an integer number n.
- Develop the **Function checkEven(n: integer): boolean** that checks if an integer number n is even.
- Develop the **Function powerXY(x, y: integer): integer** that calculates x to the power of y (x^y).

Exercise 2: Natural logarithm (06 points)

The natural logarithm (ln) can be approximated using the following formula, where $|x| \leq 1$ and n is a positive odd integer number:

$$\ln(x) = 2 * [\left(\frac{x-1}{x+1}\right) + \frac{1}{3}\left(\frac{x-1}{x+1}\right)^3 + \frac{1}{5}\left(\frac{x-1}{x+1}\right)^5 + \frac{1}{7}\left(\frac{x-1}{x+1}\right)^7 + \ldots + \frac{1}{n}\left(\frac{x-1}{x+1}\right)^n]$$